

Integrated course „Energy Economics“ - Oil Markets

Prof. Dr. Boris Heinz | Dr. Elena Timofeeva
Department for Energy Systems

Outline

- Introduction: Role of oil
- History and market structure
- Oil wholesale markets

Introduction

Crude oil has been the world's most important energy source.

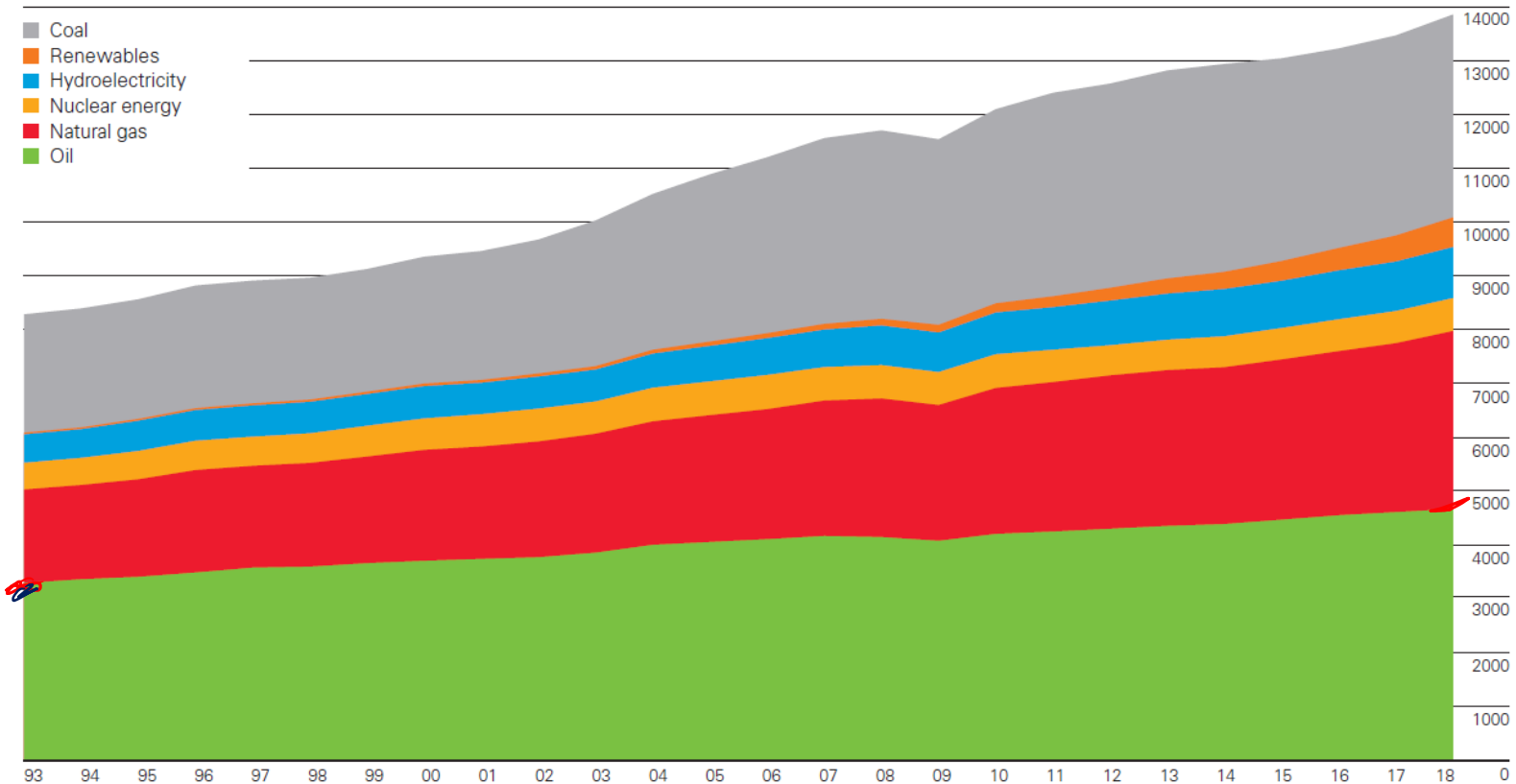
Two concerns:

- Exhaustible reserves
- Carbon emissions

Oil in World's Total Primary Energy Supply

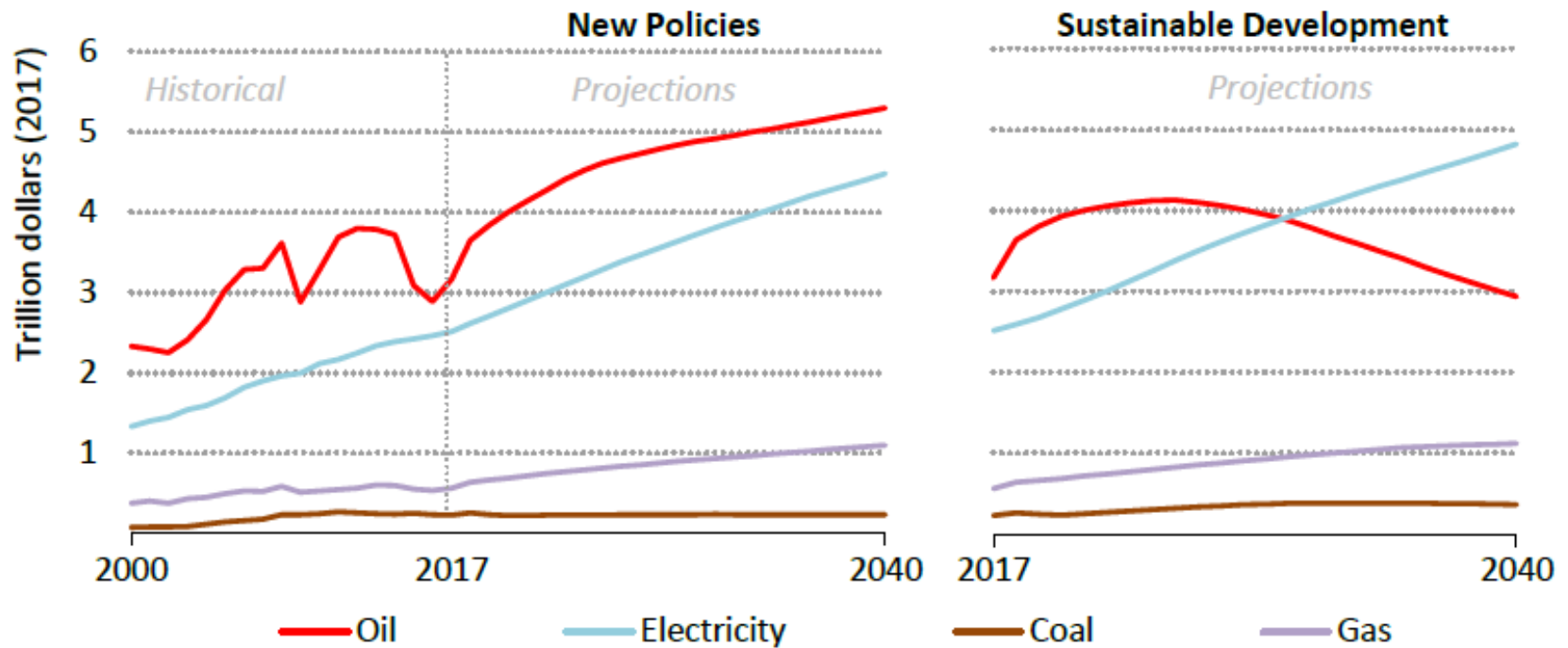
World consumption

Million tonnes oil equivalent



Source: BP (2019)

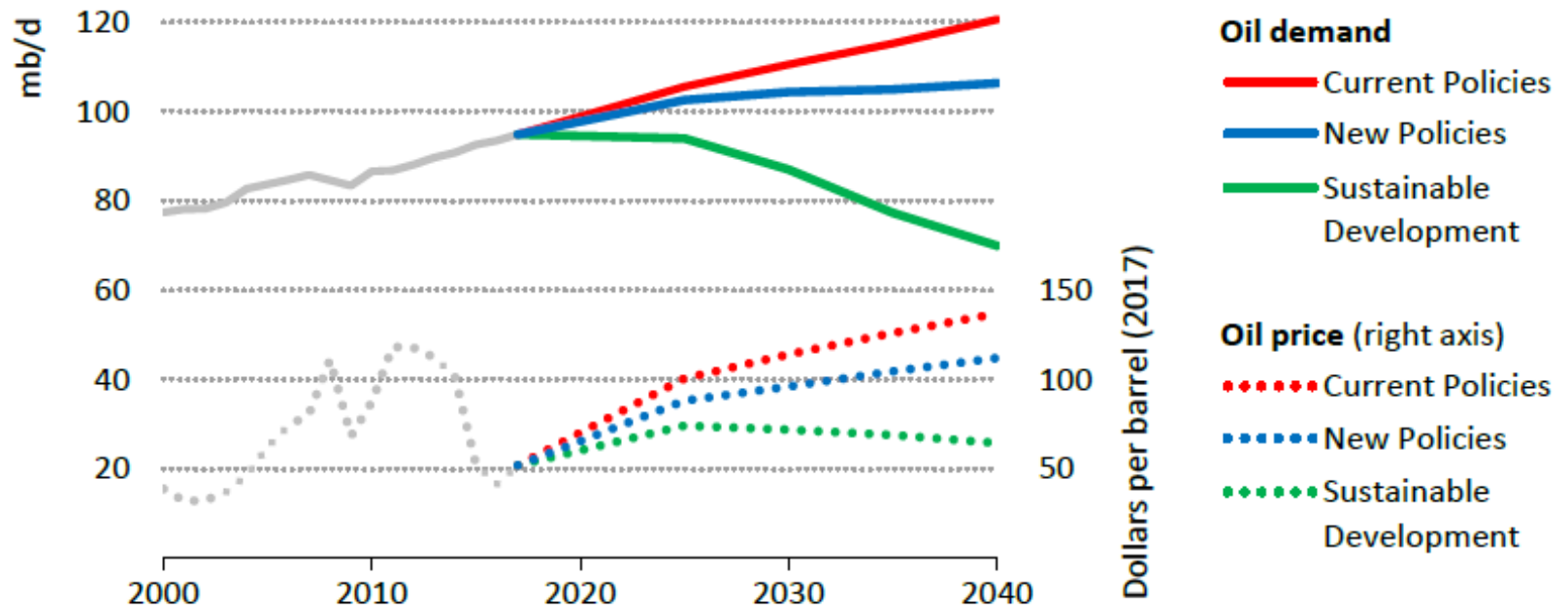
IEA Scenarios: Global End-User Energy Spending by Fuel



In the Sustainable Development Scenario, electricity takes over from oil as the main element of consumer spending on energy

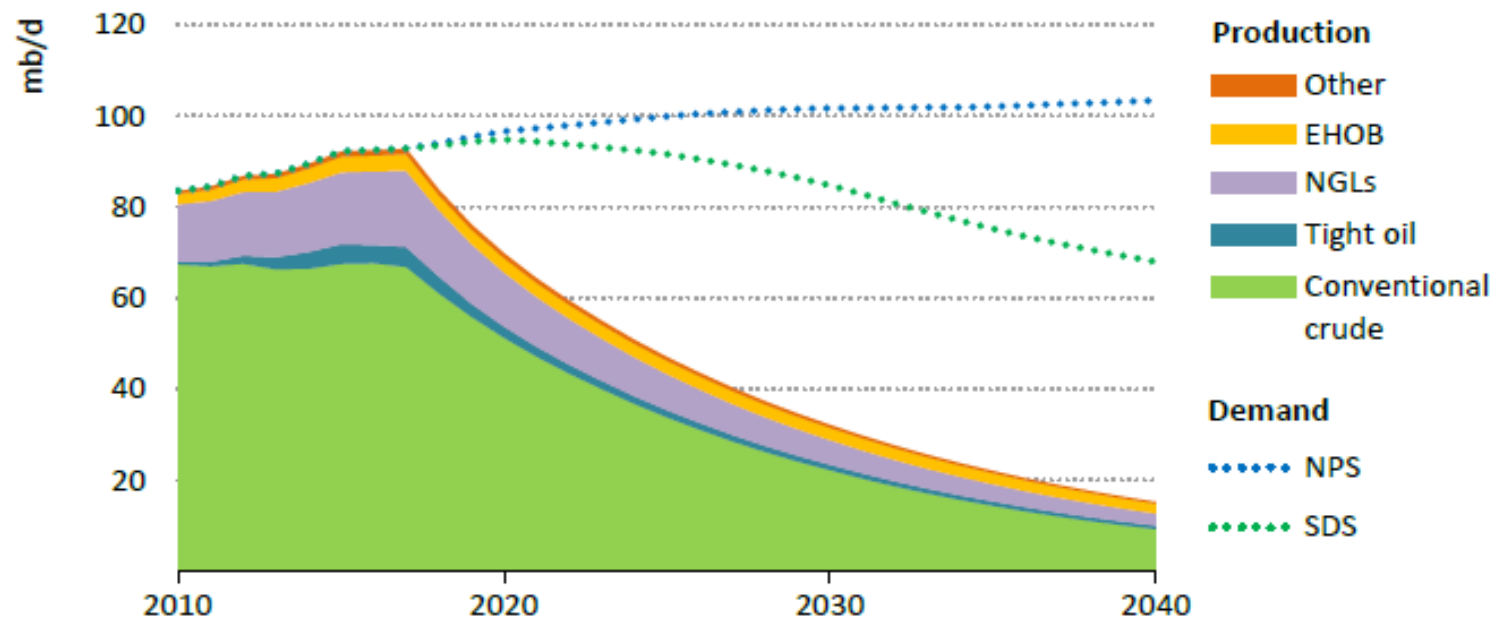
Source: IEA World Energy Outlook 2018

Global Oil Demand and Prices Projections



In 2040, oil demand in the Current Policies Scenario is 51 mb/d higher than in the Sustainable Development Scenario

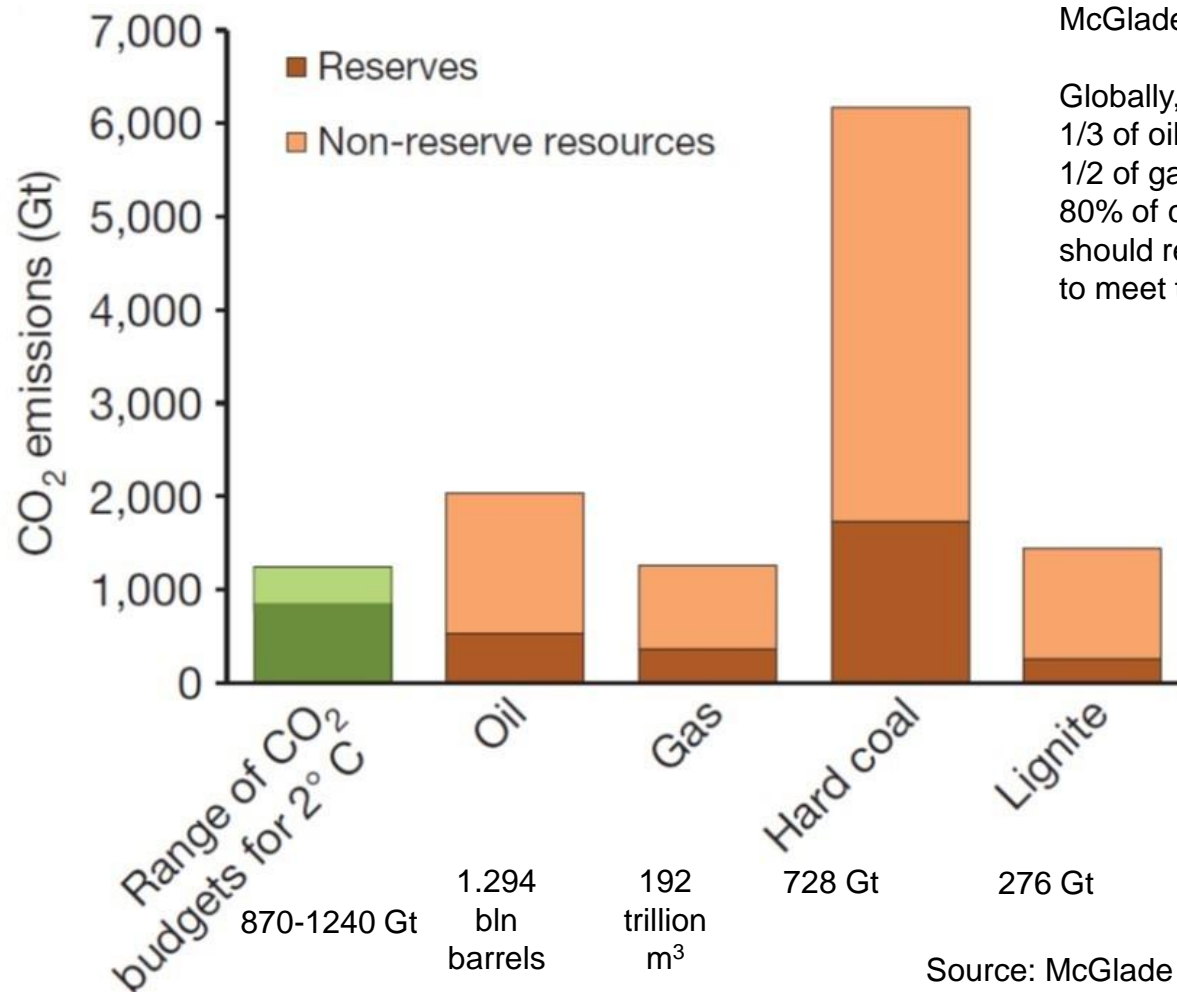
Need for New Investments



*With no new investment, global oil production would halve by 2025:
an average loss of nearly 6 mb/d every year*

Source: IEA World Energy Outlook 2018

CO₂ Emissions from Oil Combustion

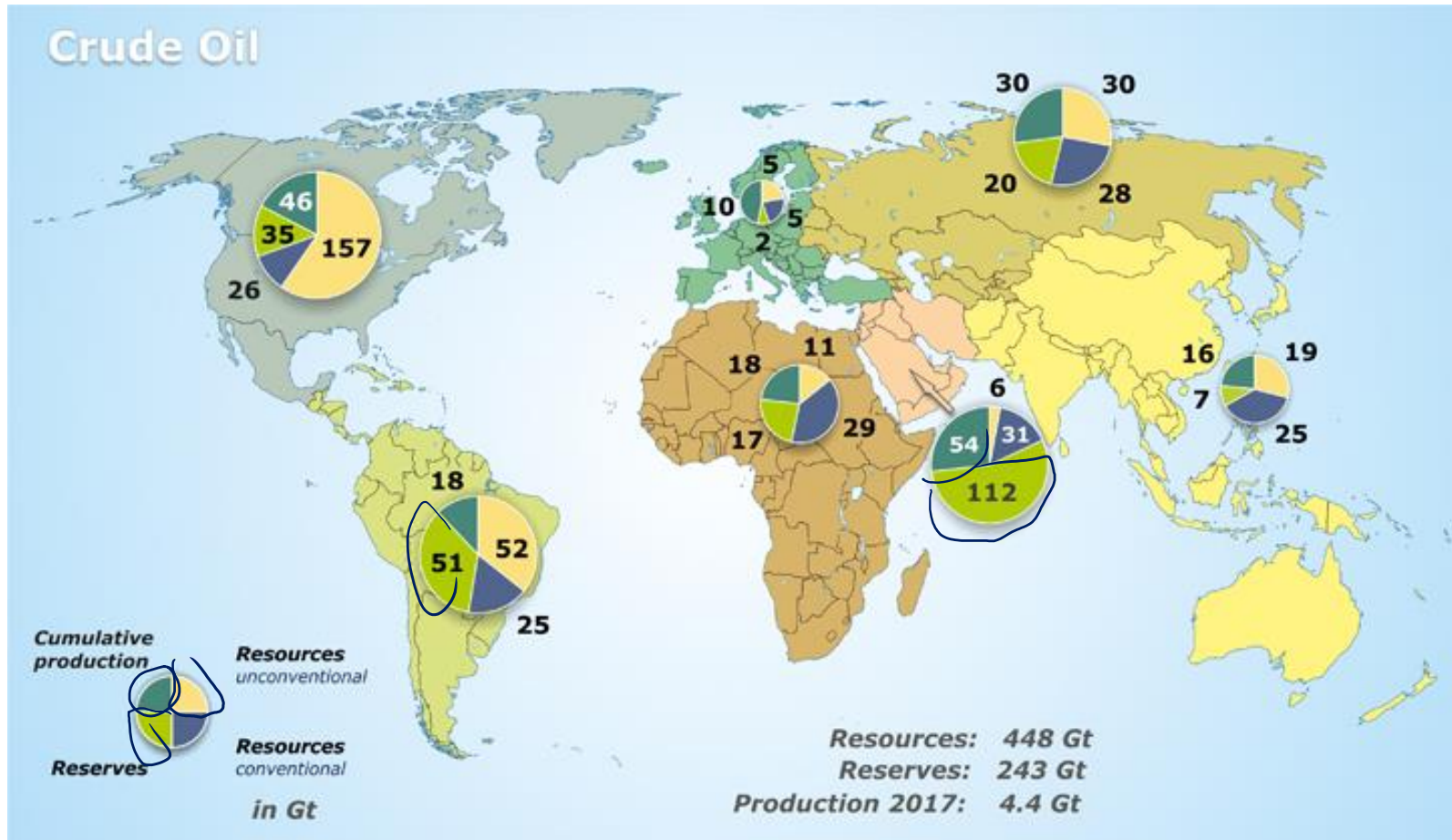


McGlade and Ekins (2015):

Globally,
1/3 of oil reserves,
1/2 of gas reserves, and
80% of coal reserves
should remain in the ground
to meet the 2° target.

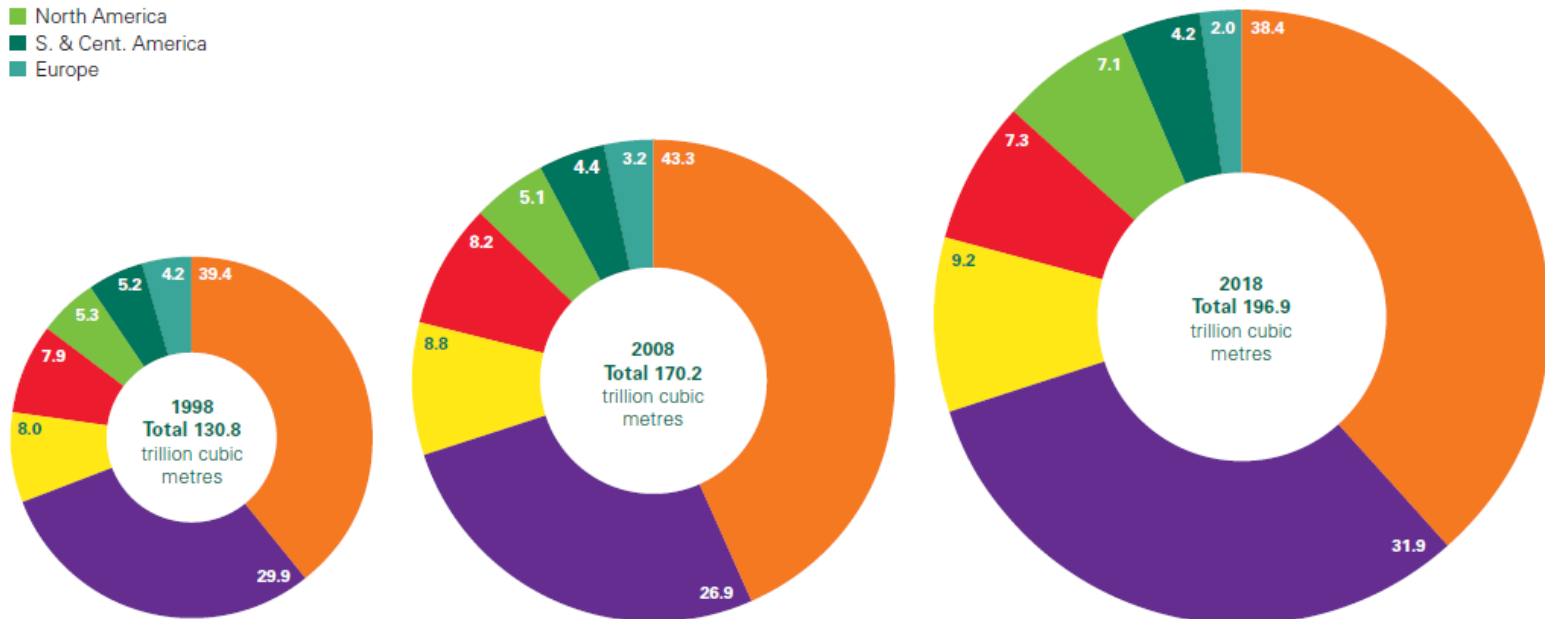
2010-2050

Total Crude Oil Potential 2017



Distribution of Oil Reserves in 1998, 2008 and 2018

- Middle East
- CIS
- Asia Pacific
- Africa
- North America
- S. & Cent. America
- Europe

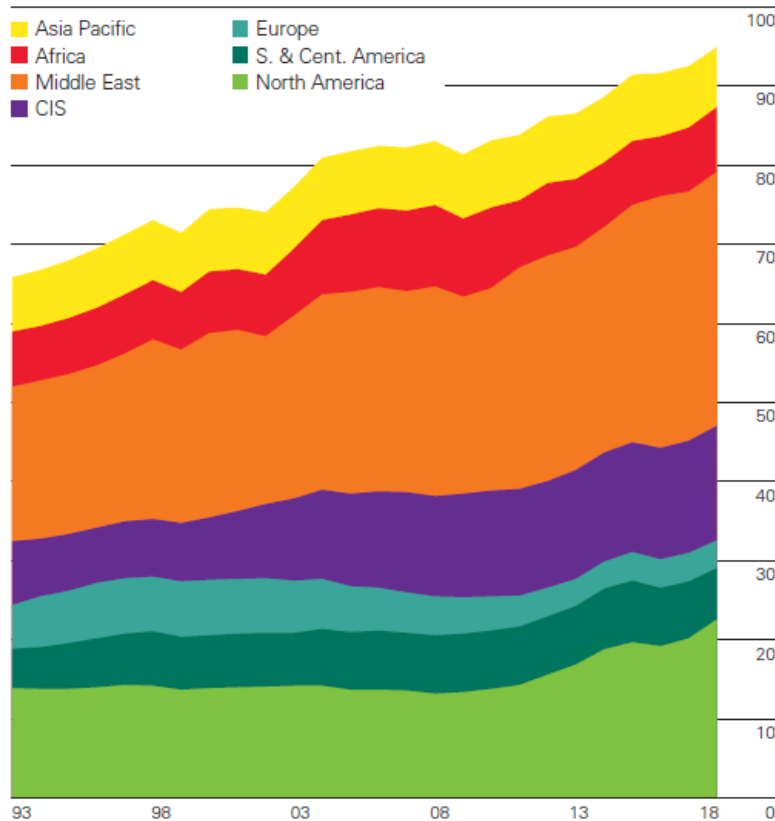


Source: BP Statistical Review of World Energy 2019

Oil Production and Consumption by Region

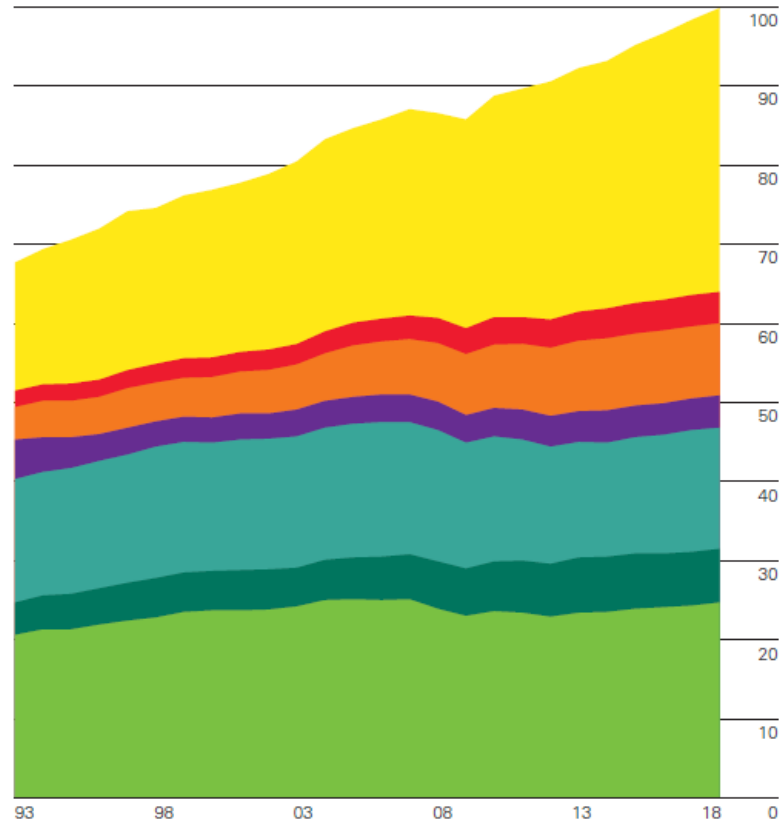
Oil: Production by region

Million barrels daily



Oil: Consumption by region

Million barrels daily

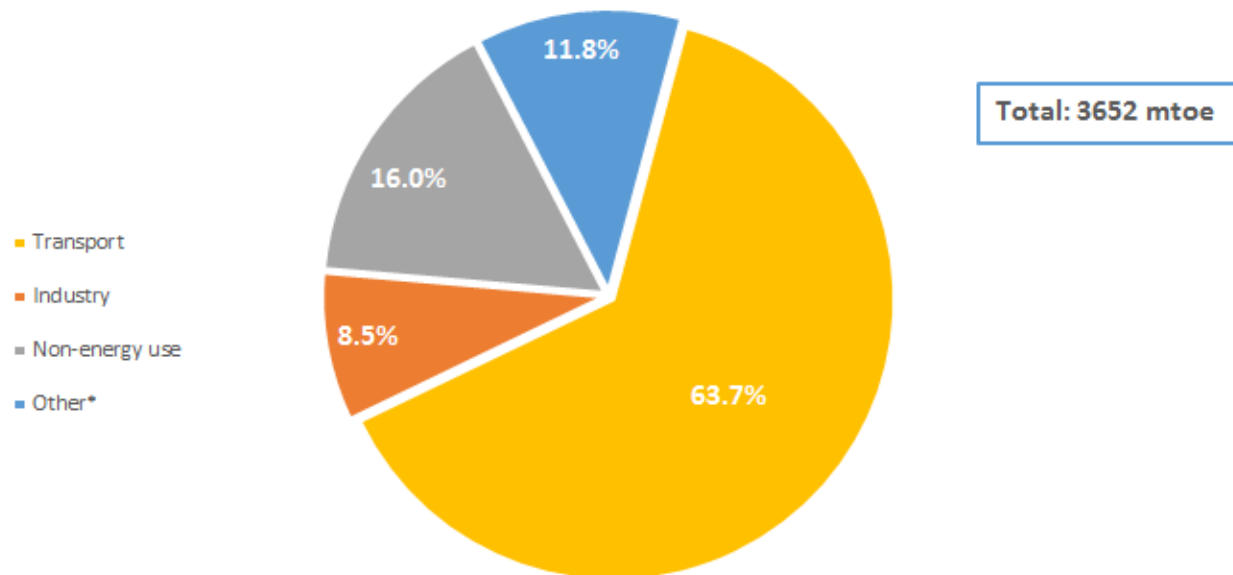


Global oil production increased by 2.2 million b/d in 2018. Growth was heavily concentrated in the US (2.2 million b/d), Canada (410,000 b/d) and Saudi Arabia (390,000 b/d) while oil production declined sharply in Venezuela (-580,000 b/d) and Iran (-310,000 b/d). OPEC production declined by 330,000 b/d while non-OPEC production increased by 2.6 million b/d. Oil consumption in 2018 grew by an above average 1.4 million b/d. China (680,000 b/d) and the US (500,000 b/d) accounted for the majority of this year's growth.

Source: BP (2019)

Oil Consumption by Sector

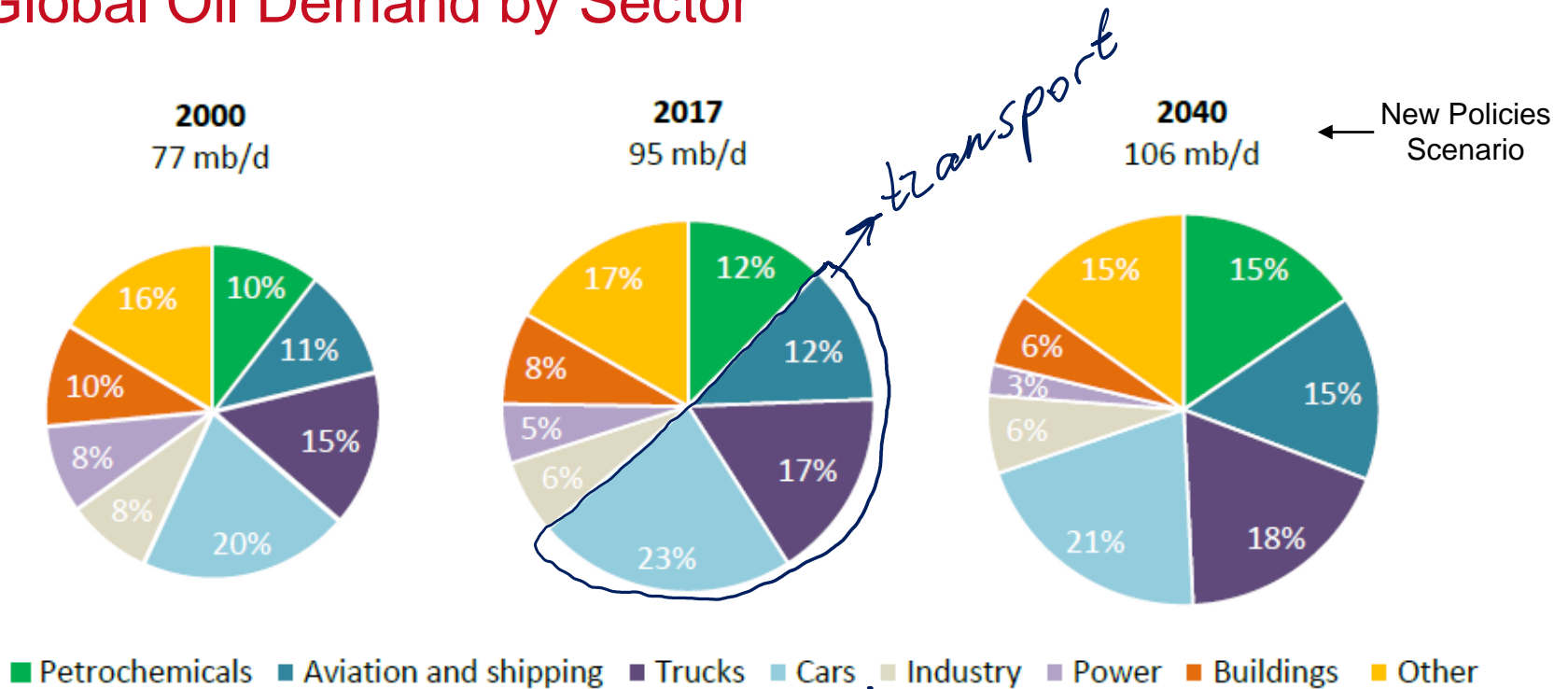
Global crude oil consumption in 2012,
breakdown by sector



*Agriculture, buildings, commercial & public services, and others.

Source: IEA Key World
Energy Statistics 2014

Global Oil Demand by Sector



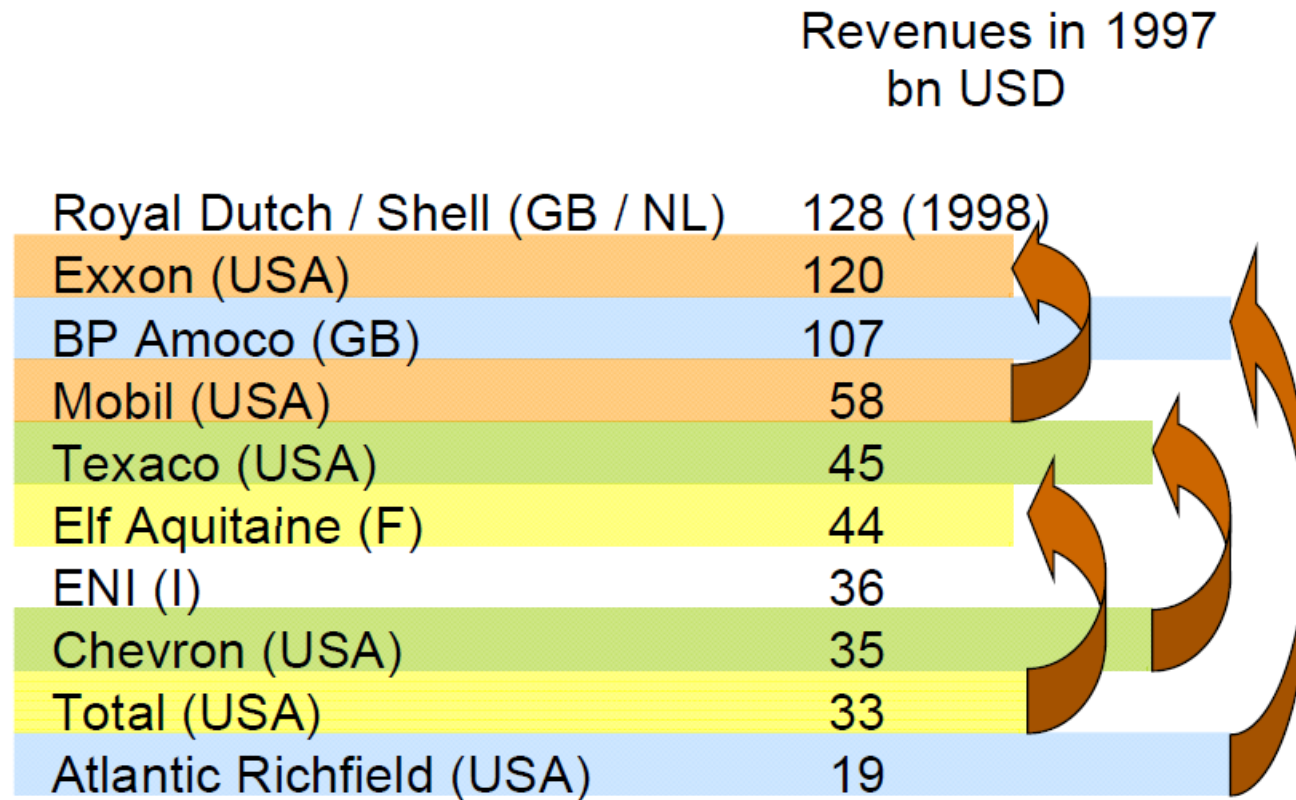
The share of petrochemicals, trucks, aviation and shipping in total oil demand grows from around one-third in 2000 to one-half by 2040

Source: IEA World Energy Outlook 2018

Transformations of the Oil Industry

- Vertical monopoly: bureaucratic decision instead of market transactions: economics of scale, factor specificity, risks of transactions along the value chain, information asymmetry, *Vertical Foreclosure*
 - 1870 Standard Oil Company (John D. Rockefeller)
 - 1911 split into 34 compalies by the Anti Trust Act
- Vertical oligopoly of the „7 sisters“ (*BP, Shell und Exxon, Mobil, Gulf und Texaco Chevron*)
 - 1928: *Achnacarry* agreement: No downstream competition – except US market
 - International tax transfer through *Posted Prices*
 - National anti trust approach and geo strategy of the US government
- *OPEC* cartel
- Oligopoly of national oil companies (NOCs)

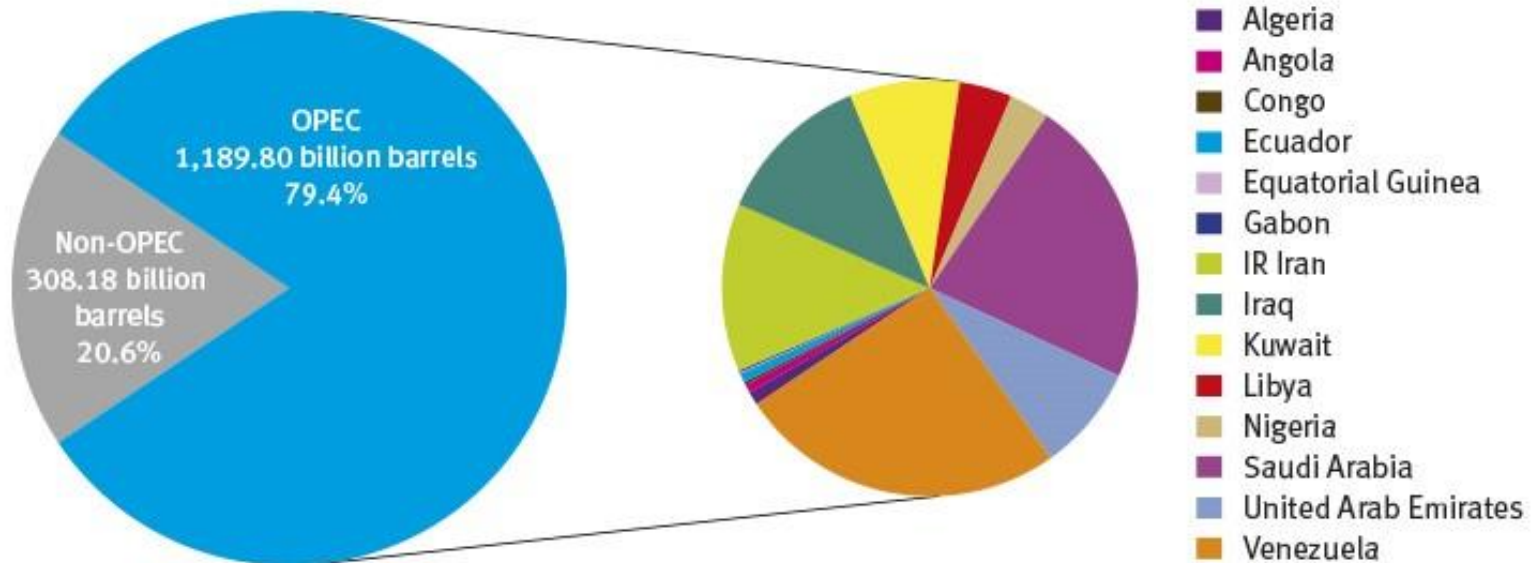
Mergers in the Oil Industry 1998-2002



Transformations of the Oil Industry

- Vertical monopoly
- Vertical oligopoly of the „7 sisters“
- OPEC cartel (Organization Petrol Exporting Countries)
 - 1960 founded by Iran, Iraq, Kuwait, Saudi-Arabia, Venezuela
 - Qatar (1961), Indonesia and Libya (1962), the United Arab Emirates Emirate (1967), Algeria (1969) and Nigeria (1971)
 - 1970-1975: Posted Price regime
 - 1976-1984: Production control by OPEC governments
 - 1985-2001: Production quotas with *Swing Producer*
 - 2002-2005: Production quotas with price corridor (22-28 USD/b)
- Oligopoly of national oil companies (NOCs)

OPEC Share of World Crude Oil Reserves, 2018



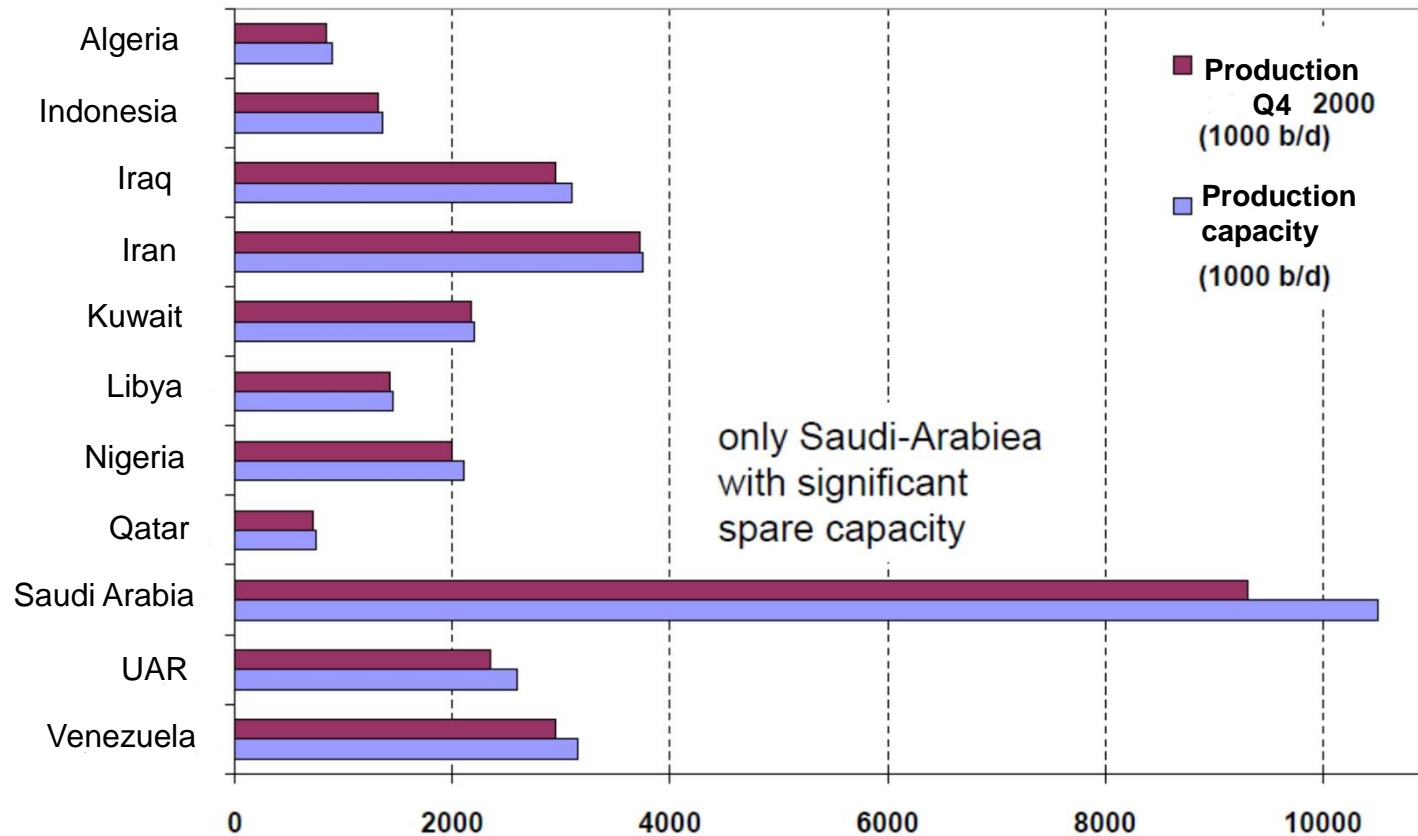
OPEC proven crude oil reserves, at end 2018 (billion barrels, OPEC share)

Venezuela	302.81	25.5%	Kuwait	101.50	8.5%	Algeria	12.20	1.0%	Gabon	2.00	0.2%
Saudi Arabia	267.03	22.4%	UAE	97.80	8.2%	Ecuador	8.27	0.7%	Equatorial Guinea	1.10	0.1%
IR Iran	155.60	13.1%	Libya	48.36	4.1%	Angola	8.16	0.7%			
Iraq	145.02	12.2%	Nigeria	36.97	3.1%	Congo	2.98	0.3%			

Source: OPEC Annual Statistical Bulletin 2019.

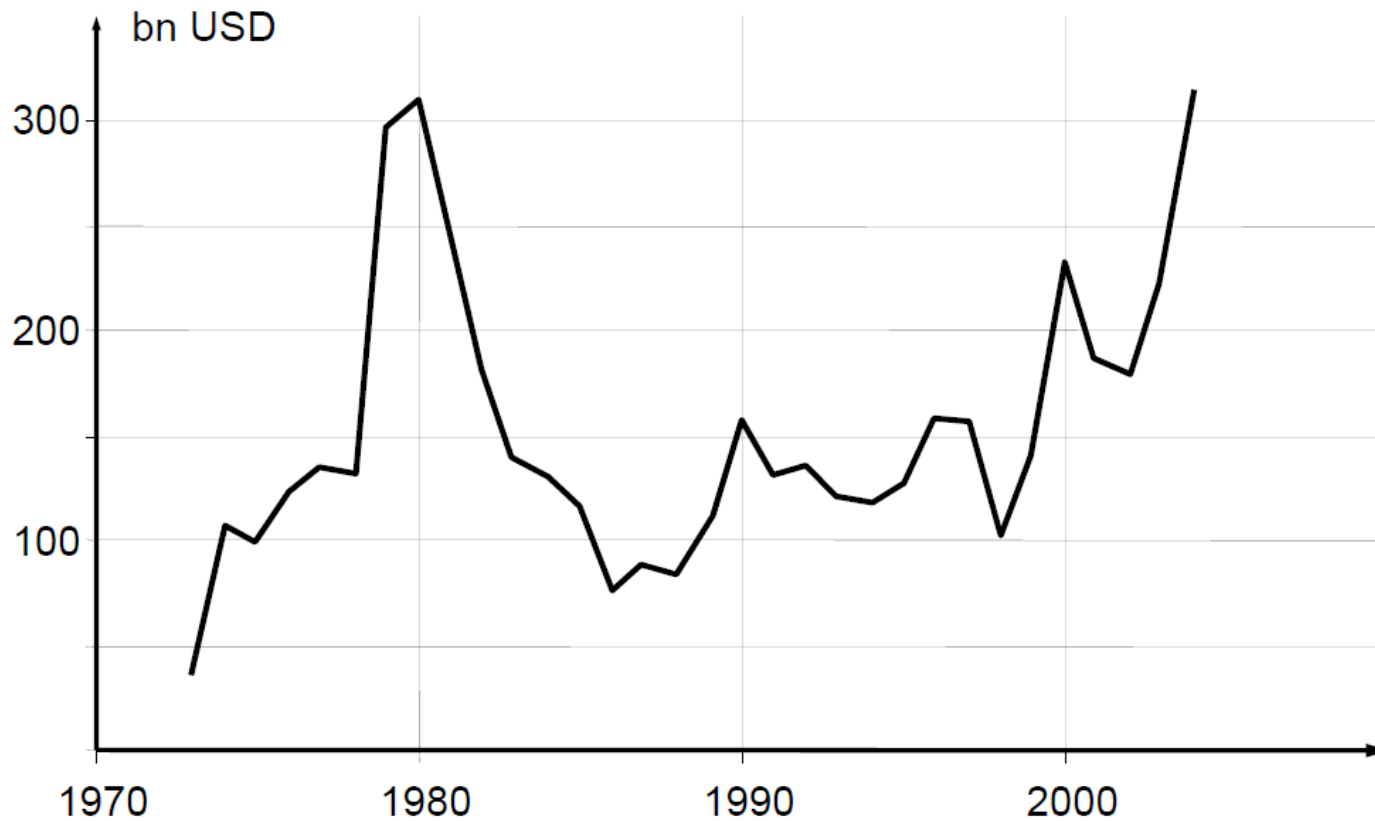
Organisation of Petrol Exporting Countries OPEC

[Source: CGES June 2006]

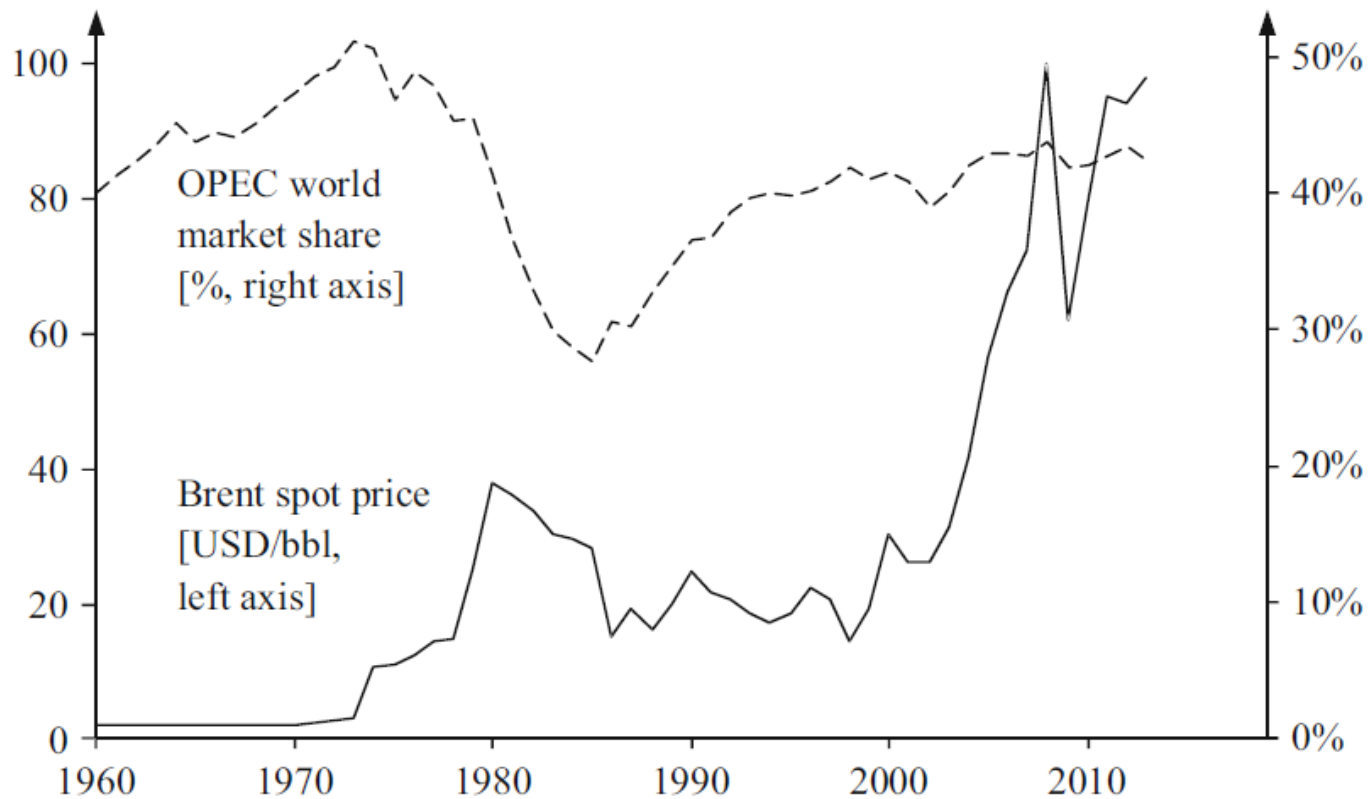


Oil Export Revenues of OPEC Countries

[Source: from DOE]



Crude oil price and OPEC market share



Zweifel/Praktiknjo/Erdmann (2017) with reference to BP

Cartels

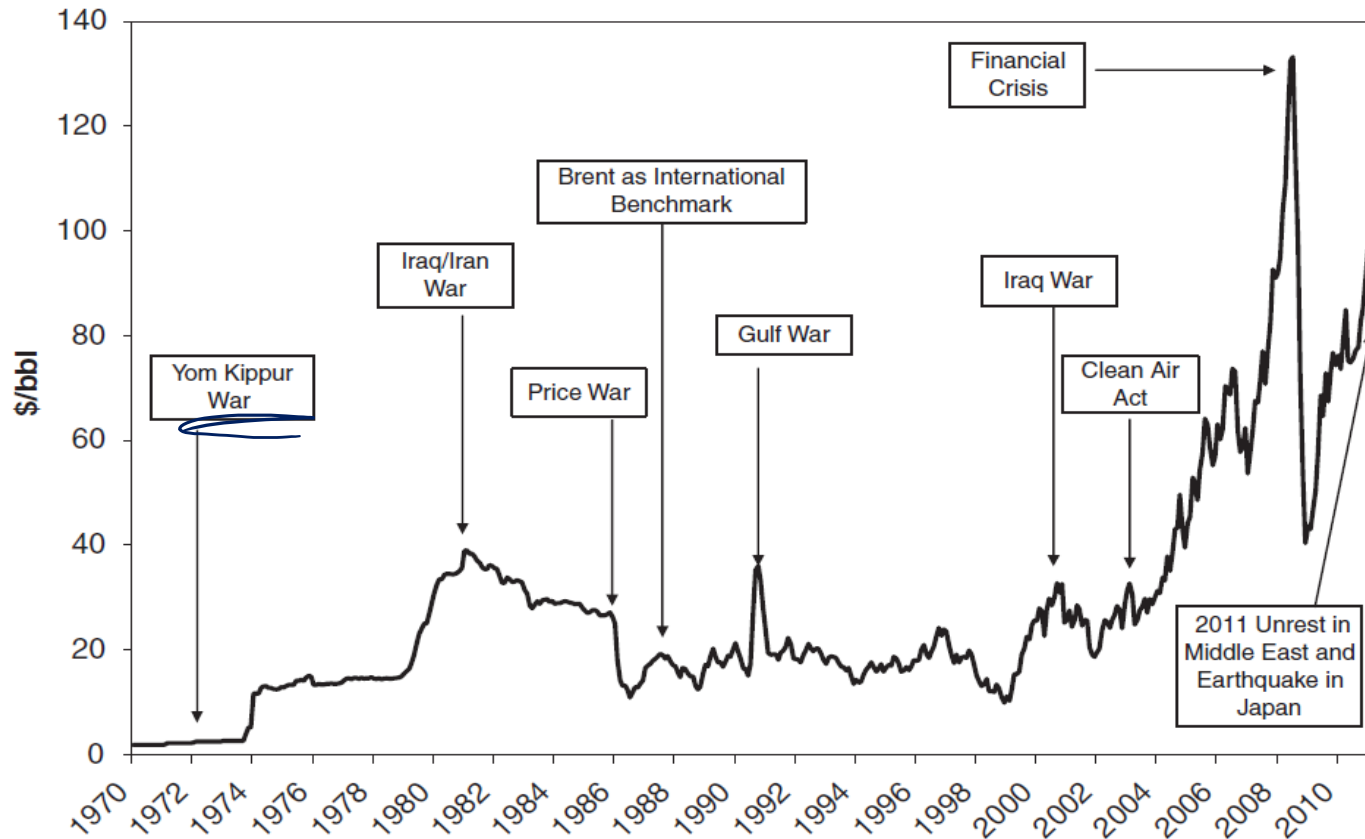
Examples

- Standardization cartels
- Marketing cartels (*Handelsvertreter-Privileg*)
- Restructuring cartels, disposal of waste cartels, ...
- Demand cartels
- Supply cartels (price cartels)

Anti trust policy

- USA: Anti-Trust-Act 1890 (Sherman-Akt, against the Rockefeller trust)
- *Law Against Competition Barriers (Gesetz gegen Wettbewerbsbeschränkungen)* of the 1950ies; applicable to Electricity and gas since the amendment of 1999 → *Monopolkommission; Bundeskartellamt, Ministererlaubnis*
- European Union: EU commission supervises competition on the internal European markets

Oil Price Development



Brent Dated 1970-2010 and main historical events

Source: Carollo (2012)

The Prisoner's Dilemma

	B stays silent (cooperates)	B betrays A (defects)
A stays silent (cooperates)	Both serve 1 year	A serves 3 years, B goes free
A betrays B (defects)	A goes free, B serves 3 years	Both serve 2 years

Stability of Cartels and the Prisoner's Dilemma

Saudi Arabia and the rest of OPEC each extract 10 mio bbl/day.

Price under cooperation: 60 USD/bbl

Price without cooperation: 40 USD/bbl

At 50 USD/bbl, each party can take over 50% of the other party's share.

Strategy of Saudi-Arabia	Strategy of other OPEC countries			
	Cooperative		Non cooperative	
	Saudi-Arabia [USD/day]	Other OPEC [USD/day]	Saudi-Arabia [USD/day]	Other OPEC [USD/day]
Cooperative	600 mio	600 mio	300 mio	750 mio
Non cooperative	750 mio	300 mio	400 mio	400 mio

Handwritten calculation: $15 \text{ mio} \times 50 = 750$ (with arrows pointing to the 750 mio cells in the table)

Introduction into Game Theory

Two companies have the choice to sell their product for a price of either $p=1, 2$ or 3 EURO. The company that offers their product for a lower price will have a higher sales quantity compared to its competitor.

Profit Matrix Company I ; Company II

	$p_{II}=1$	$p_{II}=2$	$p_{II}=3$
$p_I=1$	0; 0	50; -10	40; -20
$p_I=2$	-10; 50	20; 20	90; 10
$p_I=3$	-20; 40	10; 90	50; 50

The sum of the profits vary and can be either 100, 40, 20 or 0 in total.

Game Theoretical Terms

The **Maximising Strategy** (maximize the minimal profit):
In the previous example for $p=1$.

Should a player choose the strategy with the highest profit and this strategy remains the same under all circumstances, this strategy will be called dominant strategy. If there is a dominant strategy for every player, there is a **dominant strategy equilibrium**: If company II chooses a price $p_{II}=3$, the other company should choose a price of $p=2$, in all other cases $p=1$. There is therefore no dominant strategy equilibrium in this example.

Nash equilibrium: Situation where no player can improve his position through a change in strategies if the other player stays with his strategy. $p_I = 3$ is not a Nash equilibrium. Both could profit by choosing a lower price if the other player stays with his choice. Only $p_I=1; p_{II}=1$ is a Nash equilibrium.

Transformations in the Oil Industry (III)

Vertical monopoly

Vertical oligopoly of the „7 sisters“

OPEC cartel

Oligopoly of national oil companies

- Azerbaijan (1924), Mexico (1938), Rumania (1948), Iran (1951-1953), Indonesia (1960), Algeria (1970), Libya (1971), Iraq (1972), Iran (1973), Venezuela (1975-1990), Kuwait (1975), Saudi-Arabia (1980), Venezuela (2004), Russia (2004), Bolivia (2006)

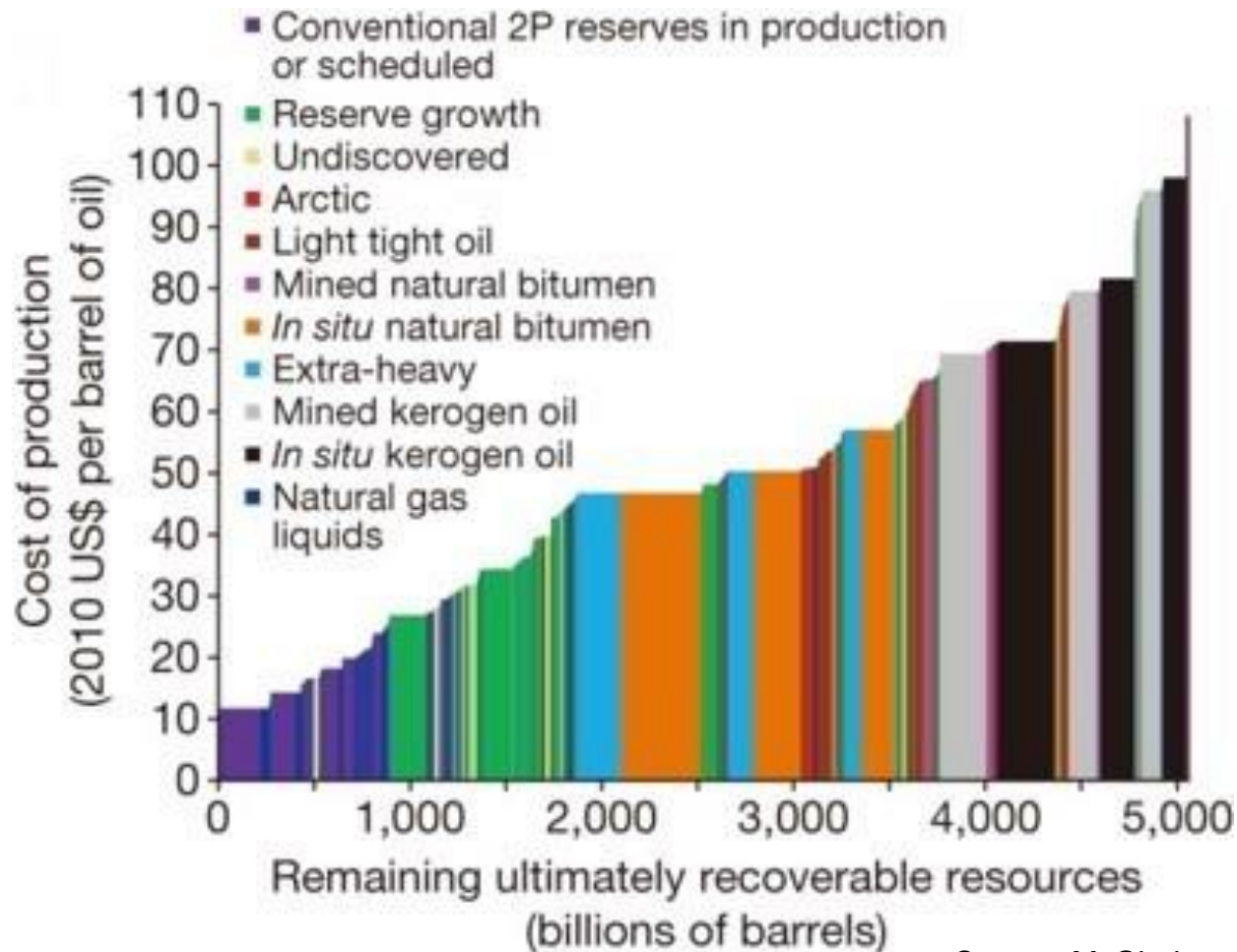
pro	con
<i>Bargaining Power</i> Sovereignty Justice („resource rent should be owned by the people“)	Lack of economic efficiency Taxes and tariffs instead of NOC returns Counteractions of import countries

Oil Sources

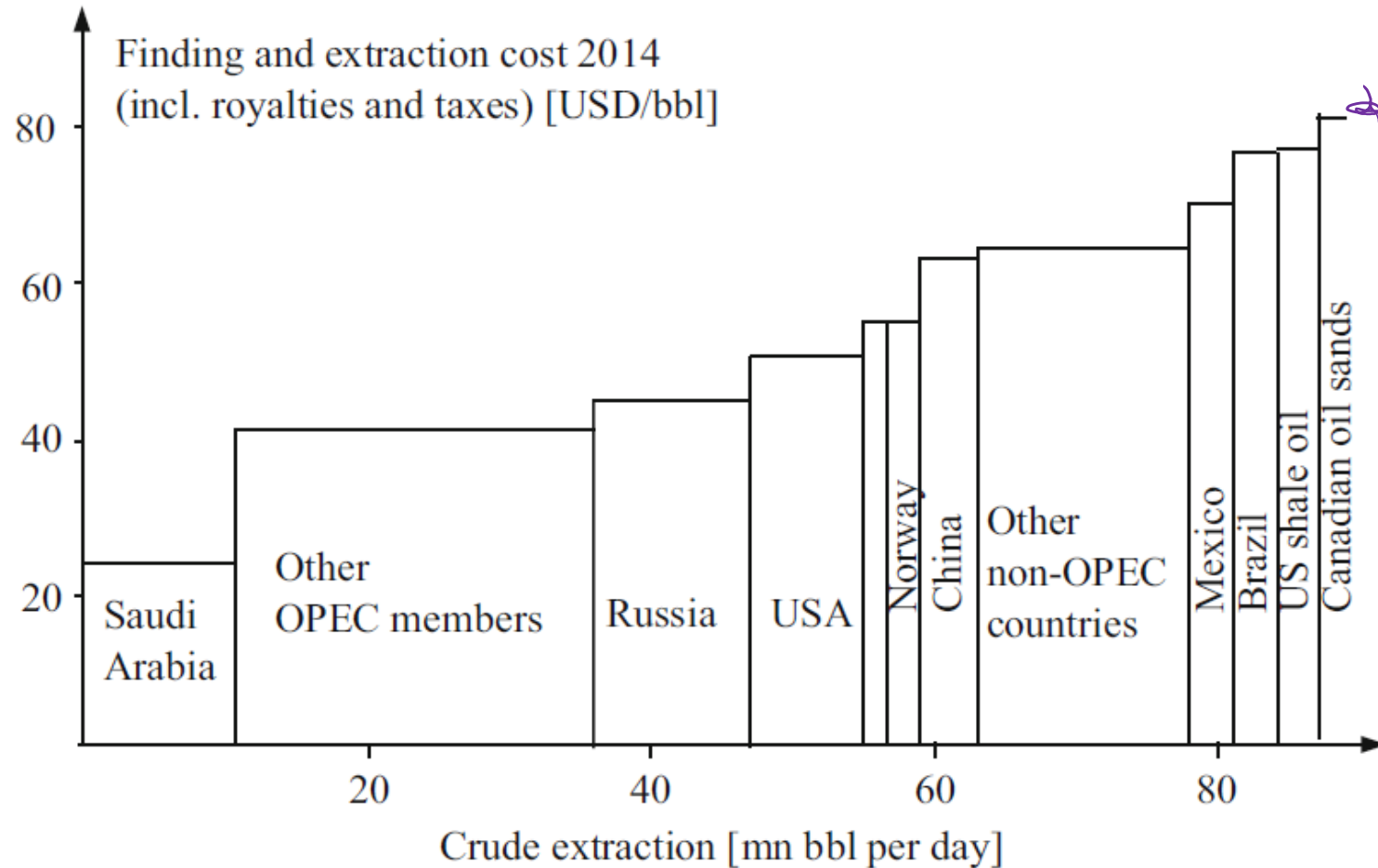
- Conventional oil

- Unconventional oil
 - Heavy crude oil
 - Oil sands
 - Bitumen
 - Tar sands
 - Shale oil (tight oil)

Cost of Production by Oil Source



Cost of Production by Country



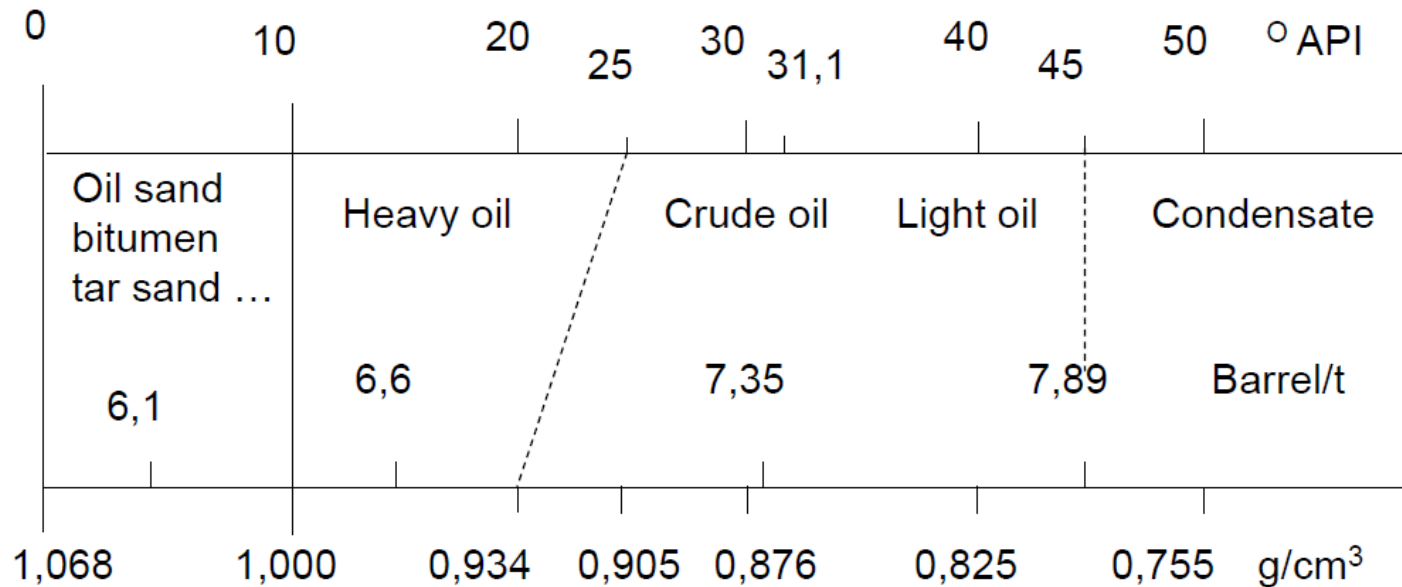
Source: Zweifel / Praktikno / Erdmann (2017) with reference to Oil Industry Trends

Crude Oil Specifications

Crude oil is a heterogeneous commodity.

- density / viscosity:
 - light oil has low density
 - heavy oil has high density (large portion of low-value products to be removed through processing)
- sulfur content:
 - sweet oil has low sulfur content
 - sour oil has high sulfur content (>0,5%)
(Price spread on different markets depend on local environmental regulations.
IMO limits sulfur content in marine fuels to max. 0,5% since 2020.)

Properties of Crude Oil Varieties



Source: American Petroleum Institute API

$$API \text{ gravity} = \left[\frac{141.5}{\text{specific gravity}} \right] - 131.5$$

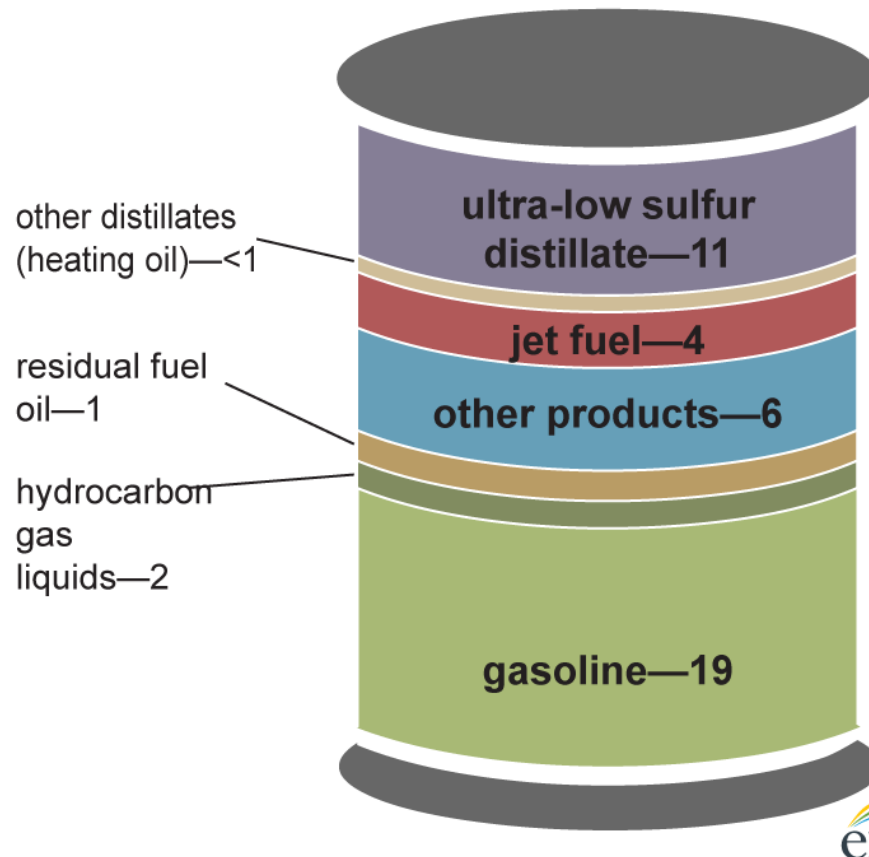
$$SG = \rho / \rho_{H_2O}$$

SG = specific gravity
ρ = density of fluid or substance (kg/m³)
ρ_{H₂O} = density of water (kg/m³)

Petroleum Products

Petroleum products made from a barrel of crude oil, 2018

gallons

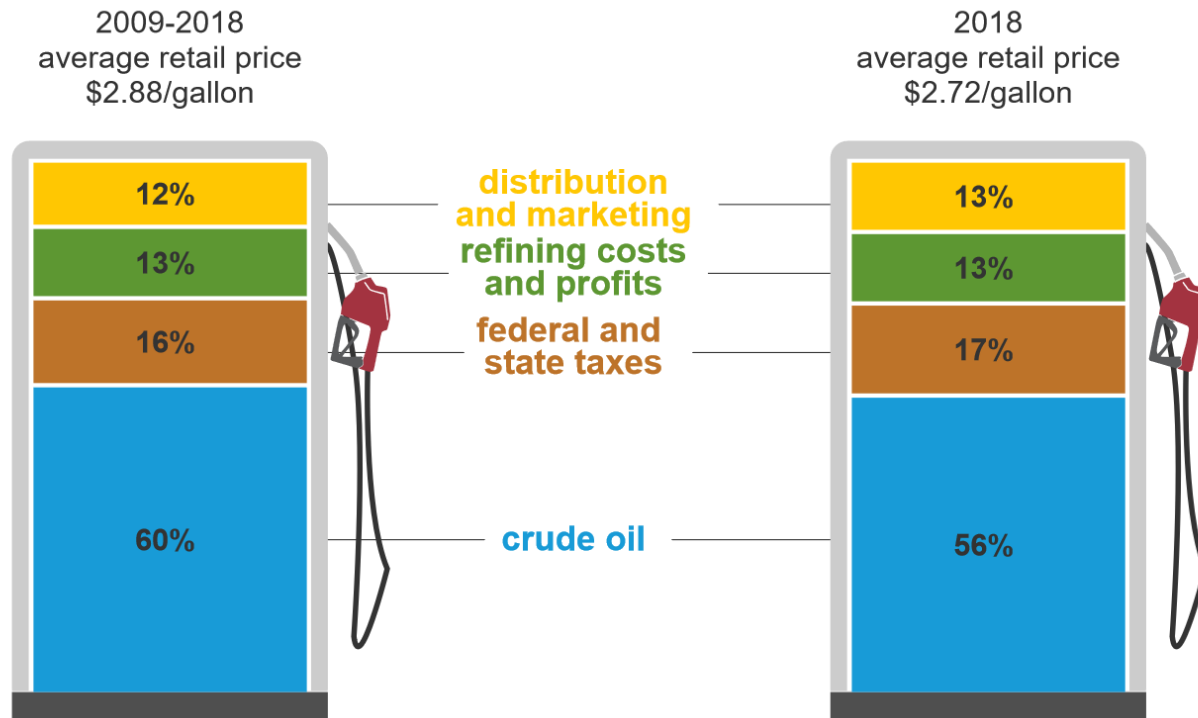


Refining: crude oil is separated into oil products through distillation.

Note: A 42-gallon (U.S.) barrel crude oil yields about 45 gallons of petroleum products because of refinery precessing gain. The sum of the product amounts in the image may not equal 45 because of independent rounding.

Source: U.S. Energy Information Administration, Petroleum Supply Monthly, April 2019, preliminary data

Gasoline Price Structure



eia Source: U.S. Energy Information Administration, *Gasoline and Diesel Fuel Update*

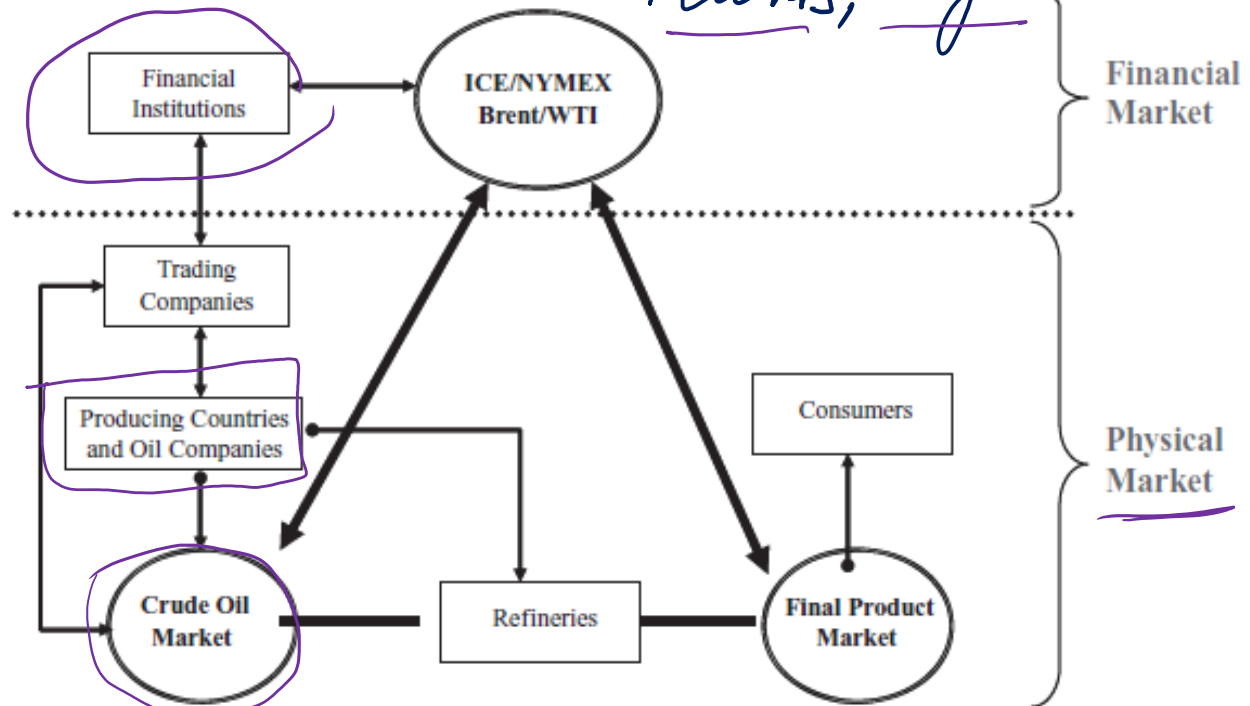
Crude Oil Product Types

- *Light distillates*: liquefied petroleum gases (LPG), naphtha, gasoline
- *Middle distillates*: kerosine, gaspol or heating oil, diesel
- *Fuel oil*
- *Others*: e.g. lubricating oils, paraffin wax, petroleum coke, bitumen

Oil Market

Market participants:

- Producers
- Refiners
- Marketers
- Retailer*
- Consumers



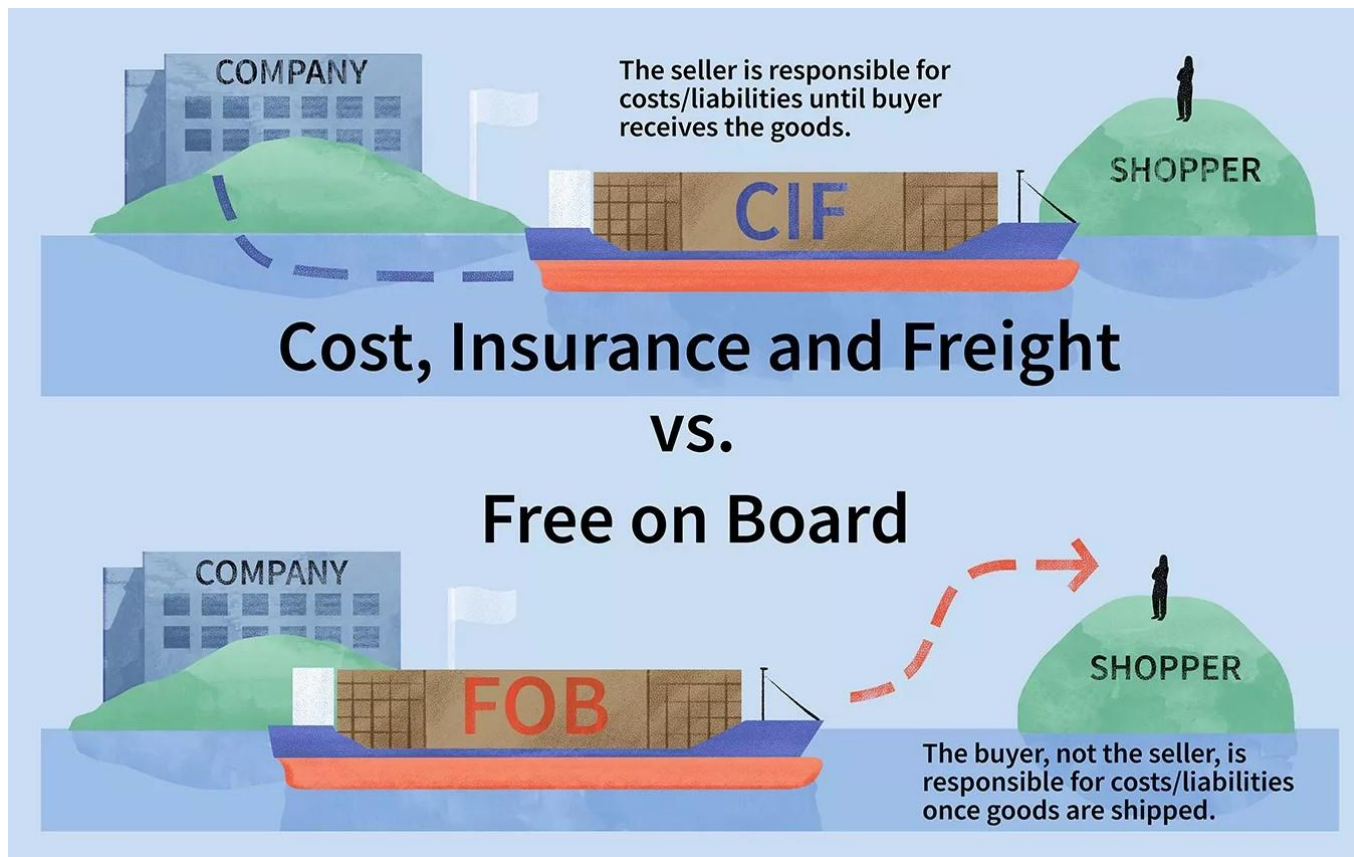
- Gasoline
- Diesel
- Jet fuel
- Fuel oil
- Chemical feedstock
- Lubricants

Source: Carollo (2012)

* oil products

Incoterms: FOB vs CIS

The geographical location of oil influences its value.

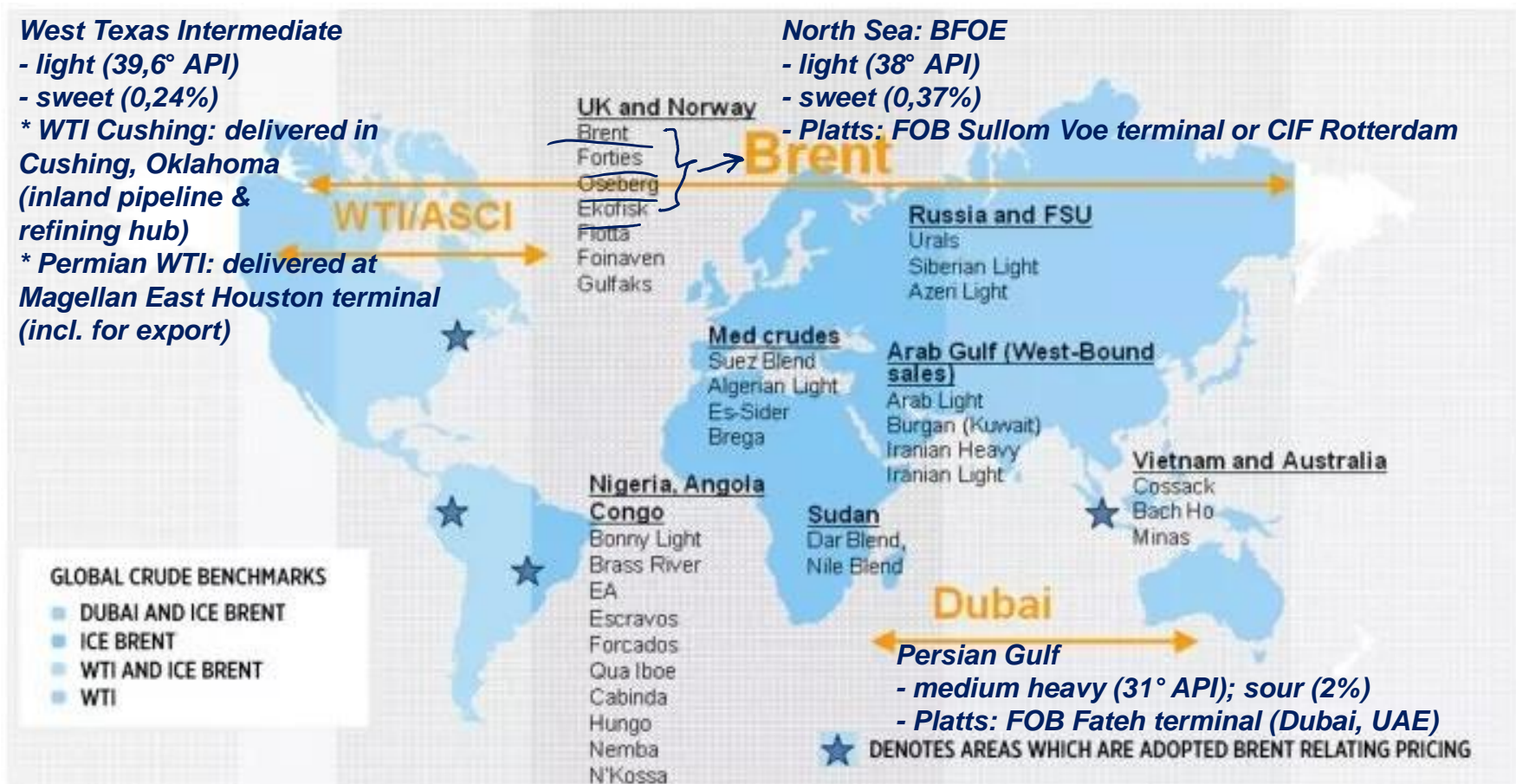


Crude Oil Benchmarks



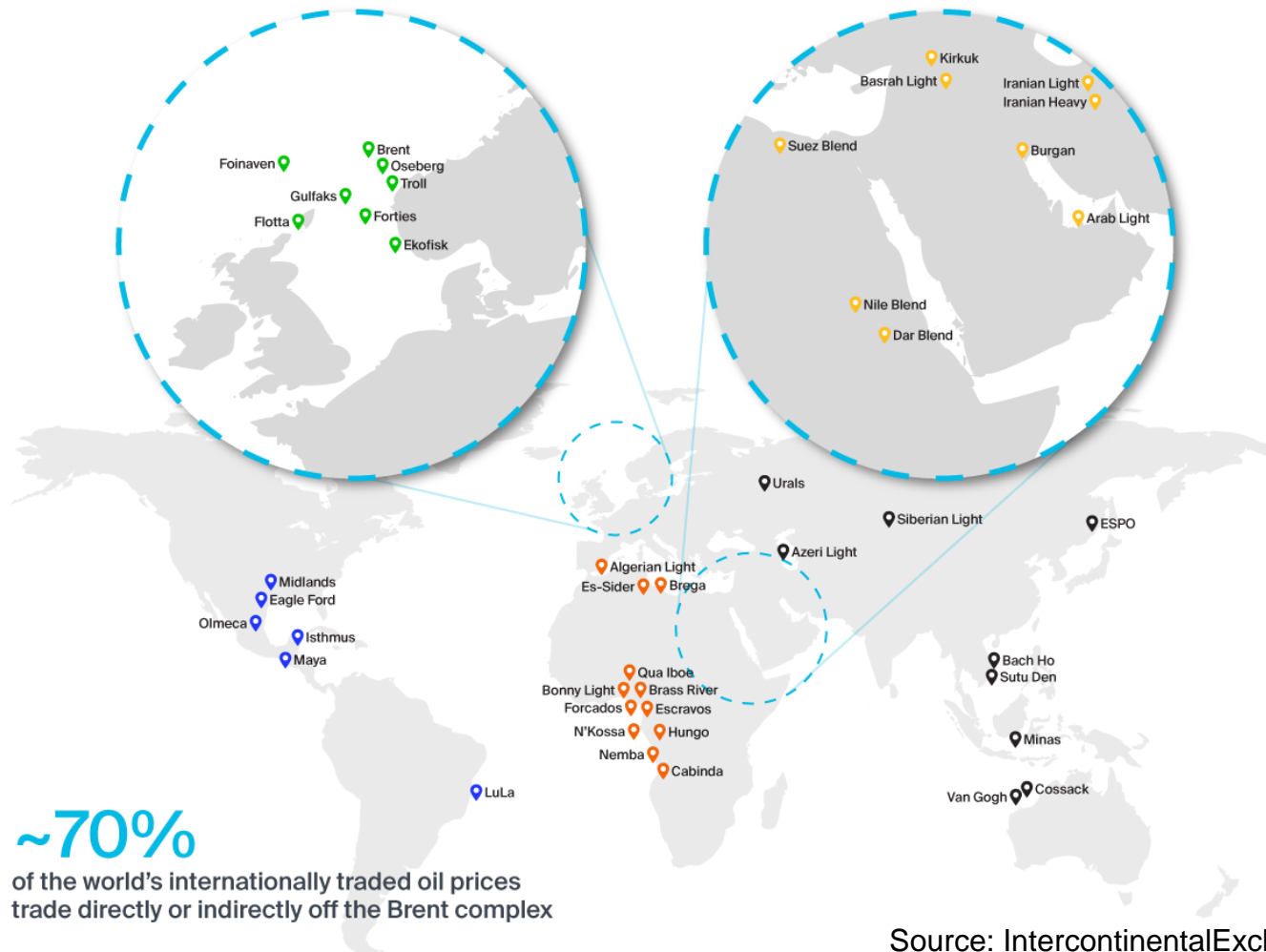
Source: IntercontinentalExchange (ICE)

Crude Oil Benchmarks



Source: IntercontinentalExchange (ICE)

Brent-related Crudes



Source: IntercontinentalExchange (ICE)

Oil Futures and Physical Prices

Crude oil futures	Size	Density	Sulphur content
WTI	1,000 barrels	Light	Low
Brent	1,000 barrels	Light	Low
Dubai	1,000 barrels	Medium	Medium
Shanghai (planned)	1,000 barrels	Medium	Medium
Physical spot market prices	Daily assessments of spot markets by Price Reporting Agencies – chiefly Platts and Argus.		
Relationship between futures and physical prices	Oil contracts can be priced according to a premium / discount to either Platts or Argus spot prices or to the futures benchmark prices. But hedging can usually only be done by taking out one of the futures contracts. Futures and spot prices will tend to move up or down together, and will converge when futures contracts become deliverable.		

Source: Trafigura

Oil Industry 2003

[Source: www.energyintel.com]

